

AMENDMENTS TO THE CLAIMS

1.-13. (Cancelled)

14. (Currently Amended) A solder bump forming apparatus adapted to use a soft solder alloy on the surface of a workpiece to form solder bumps, which will serve as connecting terminals, said solder bump forming apparatus including:

a plasma generating means adapted to generate at least hydrogen-containing plasma under a low pressure, the plasma generating means being provided with:

a high frequency power supply and an electrode connected to said high frequency power supply and adapted to generate plasma, said electrode having: a hollow electrode body adapted to receive a process gas,

supply openings that are adapted to feed the process gas and bored in an [[the]] end of the electrode body facing away from the workpiece, the supply openings being configured so that plasma proceeding through the supply openings is directed away from the workpiece, and

through holes bored through the electrode body so as to extend from the end where the supply openings are formed through to [[the]] an opposite end of the electrode body facing toward the workpiece;

a gas supply means for feeding process gas to the plasma generating means;

a workpiece exposing means for exposing the soft solder alloy on the surface of the workpiece at least to hydrogen-containing plasma; and

a heating means for applying a reflow treatment the soft solder alloy in a vacuum,
wherein the supply openings are each positioned adjacently to at least one of the through
holes, so that the plasma proceeding through the supply openings away from the workpiece passes
into the through holes moving toward the workpiece after exiting the supply openings, the through
holes being operable for trapping plasma ions in the plasma.

15. (Cancelled)

16. (Original) A bump forming apparatus as claimed in claim 14, wherein the heating means is provided with: a light source adapted to heat the backside of the workpiece by radiation, and a reflecting mirror for adjusting luminous flux from the light source.

17. (Original) A bump forming apparatus as claimed in claim 14, wherein the apparatus includes a gas recovery means that defines the flow of the gas that carries plasma generated between said electrode and another electrode to the workpiece, said gas recovery means disposed such that the workpiece is positioned between the gas recovery means and the gas supply means.

18. (Original) A bump forming apparatus as claimed in claim 14, wherein the heating means includes: a light source disposed at such a location so as not to be exposed to plasma and adapted to heat the workpiece by radiation, and a reflecting mirror adapted to form an optical path extending from the light source to the workpiece.

19. (Original) A bump forming apparatus as claimed in claim 14, wherein the apparatus includes a gas supply means for supplying a process gas, which is a mixed gas containing an inert gas and hydrogen gas that contains hydrogen with a mixing ratio of equal to or more than 3 V/V % but less than 8 V/V % calculated in terms of hydrogen molecules.

20. (Original) A bump forming apparatus as claimed in claim 14, wherein the apparatus includes a high frequency power supply having a frequency of either 13.56 MHz or 2.45 GHz.

21. (Original) A bump forming apparatus as claimed in claim 14, wherein the plasma generating means is adapted to generate fluorine-containing plasma in addition to the aforementioned hydrogen-containing plasma, said fluorine-containing plasma containing either one of or both argon and oxygen.

22. (Original) A soldering apparatus including:

a bump forming apparatus as claimed in claim 14;

a positioning means for aligning and bringing the soft solder alloy on the surface of a workpiece that has been exposed to plasma and the surface of a bonding target into contact with each other; and

a heating means for applying reflow treatment to the film of the soft solder alloy, thereby soldering the surface of the workpiece and the surface of the bonding target together.

23. (Previously Presented) A bump forming method for forming bumps, which will serve as connecting terminals, on the surface of a workpiece by following the procedure that comprises the steps of:

roughening the surface of a soft solder alloy accumulated on the surface of the workpiece;
applying a surface reforming treatment to form a layer containing fluorine on the roughened surface of the soft solder alloy; and
performing reflow of the soft solder alloy that has undergone said surface reforming treatment.

24. (Original) A bump forming method as claimed in claim 23, wherein the surface roughening treatment is performed by using plasma excitation of an inert gas to which hydrogen has been added.

25. (Original) A bump forming method as claimed in claim 24, wherein the quantity of the hydrogen added ranges from equal to or more than 3 V/V % to less than 8 V/V %.

26. (Original) A bump forming method as claimed in claim 24, wherein argon is used as the inert gas.

27. (Original) A bump forming method as claimed in claim 23, wherein the surface reforming treatment is performed by using plasma excitation of a mixed gas which contains a fluorine compound or fluorine compounds, and to which either one of or both oxygen and argon are added.

28. (Original) A bump forming method as claimed in claim 27, wherein the fluorine compound consists of at least one of the compounds selected from among carbon fluoride compounds, sulfur hexafluoride and nitrogen trifluoride.

29.-40. (Cancelled)

41. (Original) A bump forming apparatus including:

a surface roughening device for roughening the surface of a soft solder alloy accumulated on a workpiece;

a surface reforming device for performing surface reforming treatment by forming a fluorine containing layer on the roughened surface of the soft solder alloy; and

a thermal melting unit for performing reflow of the soft solder alloy having the reformed surface, thereby forming solder bumps, which will serve as connecting terminals, on the surface of said workpiece.

42. (Original) A bump forming apparatus as claimed in claim 41, wherein: the surface roughening device is a plasma exciting device adapted to roughen the surface of a soft solder alloy by means of plasma excitation, and the plasma exciting device and the surface reforming device are respectively operated in separate and different atmospheres without a pause between operation of the plasma exciting device and the operation of the surface reforming device.

43. (Original) A presoldering treatment apparatus including:

a surface roughening device for roughening the surface of solder bumps of a soft solder alloy formed on a workpiece, and

a surface reforming device for performing surface reforming treatment by forming a fluorine containing layer on the roughened surface of the solder bumps.

44. (Original) A presoldering treatment apparatus as claimed in claim 43, wherein: the surface roughening device is a plasma exciting device adapted to roughen the surface of a soft solder alloy by means of plasma excitation, and the plasma exciting device and the surface reforming device are respectively operated in separate and different atmospheres without a pause between operation of the plasma exciting device and the operation of the surface reforming device.

45. (Original) A presoldering treatment apparatus as claimed in claim 43, wherein the surface roughening device is adapted to roughen the surface of the solder bumps of the soft solder alloy in a mechanical way.

46. (Original) A soldering apparatus which is adapted to solder together a plurality of workpieces and includes:

a surface roughening device for roughening the surface of solder bumps of a soft solder alloy formed on one or more workpieces;

a surface reforming device for performing surface reforming treatment by forming a fluorine containing layer on the roughened surface of the solder bumps; and

a thermal melting unit for bringing one or more workpieces having the solder bumps that have undergone the surface roughening treatment and the surface reforming treatment into contact with other workpiece or workpieces and, in this state, performing reflow of these workpieces.

47. (Original) A soldering apparatus as claimed in claim 46, wherein: the surface roughening device is a plasma exciting device adapted to roughen the surface of a soft solder alloy by means of plasma excitation, and the plasma exciting device and the surface reforming device are respectively operated in separate and different atmospheres without a pause between operation of the plasma exciting device and the operation of the surface reforming device.

48. (Original) A soldering apparatus as claimed in claim 46, wherein the surface roughening device is adapted to mechanically roughen the surface of the solder bumps of the soft solder alloy.

49.-54. (Cancelled).

55. (Previously Presented) A bump forming method as claimed in claim 24, wherein the surface roughening treatment increases the average surface roughness Ra of the surface of the soft solder alloy to at least 0.24 μm .

56. (Previously Presented) A presoldering treatment apparatus as claimed in claim 45, wherein the surface roughening device is adapted to increase the average surface roughness Ra of the surface of the solder bumps of the soft solder alloy to at least 1.28 μm .

57. (Previously Presented) A soldering apparatus as claimed in claim 48, wherein the surface roughening device is adapted to increase the average surface roughness Ra of the surface of the solder bumps of the soft solder alloy to at least 1.28 μm .